

UNCLASSIFIED

AD NUMBER	
AD131415	
CLASSIFICATION CHANGES	
TO:	UNCLASSIFIED
FROM:	CONFIDENTIAL
LIMITATION CHANGES	
TO: Approved for public release; distribution is unlimited.	
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 04 MAR 1957. Other requests shall be referred to Aberdeen Proving Ground, MD.	
AUTHORITY	
31 Mar 1969, DoDD 5200.10; TACOM ltr, 22 Jan 1982	

THIS PAGE IS UNCLASSIFIED

E X C L U D E D

**FROM GENERAL CLASSIFICATION SCHEDULE
IN ACCORDANCE WITH
INFORMATION SECURITY PROGRAM REGULATION**

DATED - JULY 1972

**DOD 5000.1R & EXECUTIVE ORDER 11652
(EXECUTIVE ORDER 10501 AMENDED)**

BY

**Defense Documentation Center
Defense Supply Agency
Cameron Station
Alexandria, Virginia 22314**

DEC 1972

CONFIDENTIAL

*Reproduced
by the*

ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA



DOWNGRADED AT 12 YEAR
INTERVALS: NOT AUTOMATICALLY
DECLASSIFIED. DOD DIR 5200.10

CONFIDENTIAL

CONFIDENTIAL

A 131415

Armed Services Technical Information Agency

Reproduced by

DOCUMENT SERVICE CENTER

KNOTT BUILDING, DAYTON, 2, OHIO

This document is the property of the United States Government. It is furnished for the duration of the contract and shall be returned when no longer required, or upon recall by ASTIA to the following address: Armed Services Technical Information Agency, Document Service Center, Knott Building, Dayton 2, Ohio.

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

CONFIDENTIAL

NO. 131415

ASTIA FILE COPY



CRDAG-1327--24 Oct 51

Aberdeen Proving Ground

MARYLAND

ORBITALING

46

11

15

DEVELOPMENT AND PROOF SERVICES

Report

OCO Project No. 131415

ARMY--OS--ABERDEEN PROVING GROUND, MD--115

CONFIDENTIAL

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: DA 470.4/CCO(19 Oct 55)C
APG (C) 451.6/62

March 1957

INVESTIGATION OF THE VULNERABILITY TO
BALLISTIC ATTACK OF TWO T77 OSCILLATING TURRETS (U)
FIFTY-THIRD REPORT ON ORDNANCE PROJECT NO. TTL-5
DATES OF TEST: 10 FEBRUARY 1956 - 18 SEPTEMBER 1956

ABSTRACT

OBJECTIVE

To evaluate the protection afforded against ballistic attack by two T77 oscillating turret body castings.

SUMMARY

The two T77 oscillating turrets were subjected to resistance-to-penetration tests with 90mm and 76mm armor piercing projectiles at various angles of attack. In addition a study was made of the possibility of keying the turret with small arms fire and the chance of passage of fragments into the turret through the opening between the turret body and the skirting ring. Also a wooden wedge was placed hand-tight between the turret body and the skirting ring to determine whether oscillation could be hindered by objects of this nature. Gross weight of the castings was checked.

CONCLUSION

The cast armor of which these turrets were composed was sound, but the weight, 29,250 pounds, coupled with the ease with which the turret oscillation could be immobilized makes their adoption for use on combat vehicles somewhat questionable.

RECOMMENDATION

In view of the previously enumerated deficiencies, no further consideration be given towards adopting the T77 oscillating turrets in their present design for use on present day armored combat vehicles.

11 12
REGRAIDING DATA CANNOT BE PREDETERMINED

46
AR 345-220

2182
REGULATIONS, DO NOT WITHIN
CONFIDENTIAL

CONFIDENTIAL

INVESTIGATION OF THE VULNERABILITY TO
BALLISTIC ATTACK OF TWO T77 OSCILLATING TURRETS (U)

CONTENTS

	Page No.
INTRODUCTION	3
DESCRIPTION OF MATERIEL	4
DETAILS OF TEST	4
CONCLUSIONS	8
RECOMMENDATIONS	9
REFERENCES	10
OBSERVERS	11
DISTRIBUTION	12
APPENDIX A , Correspondence	A-1
APPENDIX B , Physical Test Laboratory Report	B-1
APPENDIX C , Detailed Test Data	C-1
APPENDIX D , Photographs	D-1

CONFIDENTIAL

I. INTRODUCTION

A. DISCUSSION

1. The interest displayed, in recent years, in the oscillating type of tank turret has been fostered by certain desirable design features which should add to its effectiveness in combat. The basic principle of operation of the oscillating turret is that the oscillating crew compartment, which mounts the weapon, moves in elevation and depression on two trunnion pins anchored to a ring surrounding the base of the oscillating section. With this up-and-down oscillation motion the gun moves with the turret and will always recoil into the same space in the crew compartment thereby making the use of automatic loading devices practical. Another theoretical advantage of the oscillating turret is that with the recoil of the weapon confined to a given area the size of the turret could be reduced, thereby resulting in a lower silhouette and possibly desirable weight savings.

2. Previously six T69 oscillating turrets were submitted by the Rheems Manufacturing Company to the Proving Ground for a series of ballistic tests. These tests included resistance-to-penetration, keying and locking from small arms fire of close tolerance surfaces, and the possibility of blast and fragments entering the turret between the oscillating section and the skirting ring. These tests were completed and the results published in Armor Test Report No. AD-1186 titled "Investigation of the Vulnerability to Ballistic Attack of Oscillating Tank Turrets".

3. The results of these tests indicated certain design weaknesses inherent with the T69 oscillating turret. Some of the deficiencies noted were (1) a low level of protection furnished by the area under the gun shield opening when attacked with projectiles of the 90mm AP T33 and 90mm HVAP M304 class; (2) a direct flank attack on the trunnion assembly with the 90mm AP T33 projectile at 2000 fps resulted in severe damage to the trunnion bearings preventing further elevation and depression of the gun; (3) the close tolerance between the skirting ring and oscillating section was undesirable due to the petalling from armor piercing projectiles extending over the skirting ring and hindering further depression of the gun; (4) also, this same opening between the skirting ring and oscillating section was extremely vulnerable to fragments and/or blast from small arms, fragmentation grenades, and 37mm HE projectiles entering the interior of the turret when a nylon splash shield was not present to trap these fragments and blast.

4. Recently two oscillating turrets T77 were subjected to ballistic tests at the Proving Ground. These turrets were designed by the Rheems Manufacturing Company and theoretically incorporated the recommendations made by the Proving Ground in armor test Report No. AD-1186. These tests have been completed and are the basis of this report.

CONFIDENTIAL

II. DESCRIPTION OF MATERIEL

A. MATERIEL TESTED

Two cast oscillating turrets for the 120mm gun developed by Rheems Manufacturing Company; test turret No. 1, casting Serial No. 1; and test turret No. 2, casting Serial No. 3.

B. GUNS AND TUBES USED

1. Gun, 90mm, T125, No. 4 with Tube, 90mm, T125, No. 38645
2. Gun, 76mm, T91E3, No. 336, with Tube, 76mm, T91E3, No. 24235
3. Gun, 37mm, M3A1, No. 8649, with Tube, 37mm, M3A1, No. 120006
4. Rifle, Accuracy, Mann Type, Caliber .50, No. 170 with Receiver No. 46.

C. AMMUNITION

1. Shot, AP, 90mm, T33E7 with Windshield, Lot RTQ-4-16
2. Shot, HVAP, 90mm, M304 with Windshield, Lot YEM-3-4
3. Shot, AP, 76mm, T128E6 with Windshield, Lot NSC-5-50
4. Shell, H.E., 37mm, M54 with Fuze, PD, M56, Lot LOD-SR-3
5. Bullet, AP, Caliber .50 M2, Lot - Stock
6. Grenade, Hand, Fragmentation, MK2 (TNT Loaded) without fuze, Lot IS-SR-7

III. DETAILS OF TEST

A. PROCEDURE

1. Prior to all testing, the two oscillating turrets were measured for thickness by means of a supersonic reflectoscope. The turrets were marked off in approximately 10" x 10" squares and numbered for future reference. A smooth spot was ground as close to the center of each square as surface conditions would permit so that all measurements could be taken with the reflectoscope. One measurement was made in each block and a list of these measurements may be found for each turret in the Aberdeen Proving Ground Physical Test Laboratory Report contained in Appendix B.

CONFIDENTIAL

2. During the ballistic tests, each casting was mounted on a large turntable to allow the turret to be revolved so as to present the desired angle of attack. Each turret was attacked frontally and at various flank angles measured from the longitudinal axis of the turret.

3. The protection ballistic limit criterion was used as a basis for all testing. This criterion defines a complete penetration as one where the projectile impact causes metal to be displaced from the back of the plate or the condition where projectile fragments pass beyond the back of the plate. A partial penetration is defined as one which does not meet the requirements for a complete penetration defined above. In testing these turrets, the number of rounds which could be fired was limited by the size of the armor area. Ballistic limits were therefore determined by averaging the velocities of a complete penetration and a partial penetration which were generally not more than 50 feet per second apart.

B. RESULTS

The complete round-by-round results for each turret tested may be found in Appendix C. In view of the fact that each of the two turrets were tested using a different 90mm projectile the results for each casting will be treated separately.

1. The following tabulation summarizes the ballistic limits obtained on the T77 turret, Serial No. 1.

<u>TURRET MODEL AND NUMBER</u>	<u>SUMMARY OF RESULTS</u>		<u>AVG</u>	<u>PROTECTION</u>
	<u>CONDITION OF ATTACK</u>		<u>THICKNESS</u> <u>inches</u>	<u>BAL. LIMIT</u> <u>fps</u>
<u>T77 - No. 1</u>	<u>90mm AP T33 Projectile</u>			
"	Direct Frontal Attack - Right side		5.17"	3058
"	30° Flank Attack - Left side		2.74"	2786
"	Direct Frontal Attack- Under Gun Shield opening		No Protection Bal. Limit obtained- Low CP(P) = 2228	
	<u>76mm AP T128E6 Projectile</u>			
"	60° Flank Attack - Right side- on bustle		3.04"	2626
"	60° Flank Attack - Left side- on bustle		No Protection Bal. Limit obtained- High PP(P) = 3049	
"	90° Flank Attack- Right side- on bustle		3.10"	1426
"	90° Flank Attack- Left side- on bustle		3.22"	1553

CONFIDENTIAL

2. In addition to subjecting the above turret to the referenced resistance to penetration tests several phases of testing were conducted to investigate the entrance of fragments between the turret body and skirting ring, and the keying or locking of close toleranced surfaces by small arms fire.

3. Prior to detonating any HE shells or grenades the opening between the turret body and skirting ring was enclosed with tin foil to check the extent to which fragments could enter the inside of the turret through this opening. In this phase three MK 2 Fragmentation Grenades and two 37mm HE M54 projectiles were detonated around the circumference of the turret. Each round succeeded in completely destroying the tin foil on detonation, indicating a very hazardous opening between the two main parts of the turret.

4. Eight rounds of caliber .50 AP M2 were fired against turret No. 1. None of the rounds which impacted under the gun shield opening gave enough petalling to hinder the operation of the turret. One round which was fired from a direct rear attack into the close toleranced surfaces between the trunnion bearing faces completely jammed the oscillation of the turret. A drawbar strain gauge* reading of 7484 lbs. was obtained with the projectile core locking the turret. In a free lift after the core was cut out a reading of 6073 lbs. was obtained with the same gauge.

5. Each of the four rounds of 90mm AP T33E7 projectiles fired so as to impact in the area under the gun shield opening, with the turret in maximum elevation, resulted in complete immobilization of turret oscillation. Projectile fragments from the first round lodged between the turret body and skirting ring so tightly the body could not move. A drawbar strain gauge reading of 9375 lbs. was recorded but no movement of the turret was noted. The three remaining impacts resulted in face petalling extending over the skirting ring making it impossible to depress the turret before this petalling was removed with a cutting torch.

6. Both of the trunnion bearings were subjected to a 90° flank attack, measured 90° off the longitudinal axis of the turret, with the 90mm AP T33 projectile. The right trunnion cap was impacted at a striking velocity of 2007 fps. The turret was immobilized with no apparent damage on the interior. The left trunnion was impacted at a striking velocity of 2004 fps. An oil leak around the trunnion hub on the interior was noted. The turret was immobilized by this impact. Photograph B18291 depicts typical damage to the bearings as a result of these impacts.

7. The following tabulation summarizes the ballistic limits obtained on the T77 turret, Serial No. 3.

* The drawbar strain gauge was positioned vertically, and attached to the ventilator opening on the roof of the turret bustle.

CONFIDENTIAL

SUMMARY OF RESULTS

<u>TURRET MODEL AND NUMBER</u>	<u>CONDITION OF ATTACK</u>	<u>AVG.</u>	<u>Protection</u>
		<u>THICKNESS</u> <u>inches</u>	<u>Bal. Limit</u> <u>fps</u>
<u>T77 - No. 3</u>	<u>90mm HVAP- M304 Projectile</u>		
"	Direct Frontal Attack- Right Side	4.20	3514
"	30° Flank Attack- Left side	3.00	2880
"	Direct Frontal Attack- Under Gun Shield opening	No BL(P) obtained Low CP(F) = 1976	

8. As with turret No. 1, several phases of testing were conducted on turret No. 3 to investigate the possibility of fragment entrance between the turret body and skirting ring and the keying of the turret by small arms fire.

9. Again, the opening between the turret body and the skirting ring was enclosed with tin foil to measure the extent to which fragments could enter the turret through this opening by blast of H E rounds or hand grenades. Three MK2 Fragmentation Grenades and two 37mm HE M54 projectiles were detonated around the circumference of the turret. Each round completely destroyed the tin foil, again indicating a very hazardous opening between the two main parts of the turret.

10. Six rounds of caliber .50 AP M2 were fired against turret No. 3. None of the rounds which impacted under the gun shield opening produced enough petalling to hinder the operation of the turret. One round was fired from a direct rear attack into the close toleranced surface between the trunnion bearing faces of the turret body and skirting ring. This round completely immobilized the oscillation of this turret. A drawbar strain gauge reading of 9450 lbs. was recorded with the projectile core locking the two surfaces together. A strain gauge reading of 6375 lbs was obtained with the core removed.

11. Each of the four rounds of 90mm HVAP projectiles which impacted in the area under the gun shield opening, with the turret in maximum elevation, resulted in complete immobilization of the turret oscillation. The petalling on the face of the casting resulting from these impacts extended over the skirting ring making depression of the turret body impossible until these petals were burned off with a cutting torch.

12. Both of the trunnion bearings were subjected to a 30° flank attack, measured 30° off the longitudinal axis of the turret, with the 90mm AP T33E7 projectile. The left bearing was impacted at a striking velocity of 2011 fps and the right bearing at a striking velocity of 2029 fps. No interior damage was noted on either impact and there was no hindrance to the movement of the turret due to these two impacts.

CONFIDENTIAL

C. OBSERVATIONS

1. The T77 oscillating turret, serial No. 1, was weighed at the Proving Ground and a weight of 29,250 lbs. recorded.

2. In an effort to determine the vulnerability of the T77 turret design to nondestructive attack, a two-foot long, narrowly-tapered, oaken wedge was inserted hand-tight between the turret body and the skirting ring. With this wedge in place it was impossible with the equipment on hand to elevate or depress the turret, illustrating the ease with which this turret could conceivably be temporarily immobilized by guerrillas. A fabric cover over this opening, however, could probably prevent such immobilization.

IV. CONCLUSIONS

Based upon the results of this test it is concluded that:

A. No excessive back spalling or cracking occurred in the frontal areas attacked with the 90mm projectiles or the side areas attacked with the 76mm projectiles, indicating the armor in these areas was sound and provided a satisfactory limit of protection.

B. The large opening between the skirting ring and turret body casting presents an opening for the passage of fragments into the fighting compartment. However, tests with the T69 oscillating turret indicate that a properly-installed nylon splash shield can effectively protect against most of this danger.

C. The weight of the bare castings of the turret and skirting ring, 29,250 lbs, would make this turret design impractical for adoption for any of the present day armored combat vehicles.

D. The vertical oscillation of the T77 turret can be prevented by small arms fire which can key the trunnion bearing surfaces, by 90mm projectiles striking under the gun shield opening, and by foreign objects placed in the opening between the turret body casting and the skirting ring.

CONFIDENTIAL

V. RECOMMENDATIONS

Based upon the results of this test it is recommended that:

In view of the excessive weight of the castings and the vulnerability of the turret to various forms of ballistic attack, no further efforts be made towards adopting the T77 oscillating turret ~~in its~~ ^{in its present} design for use on present day armored combat vehicles.

SUBMITTED:

William B. Frye
WILLIAM B. FRYE
Ordnance Technician

REVIEWED:

William C. Pless
WILLIAM C. PLESS
Chief
Armor Branch

Herbert L. Rosenberg
HERBERT L. ROSENBERG
Chief, Armor and Ammunition
Effectiveness Division

APPROVED:

H. A. Noble
H. A. NOBLE
Assistant Director
Engineering Testing
Development and Proof Services

CONFIDENTIAL

REFERENCES

Armor Test Report No. AD-1186 entitled,
"Investigation of the Vulnerability to Ballistic Attack
of Oscillating Tank Turrets."

CONFIDENTIAL

CONFIDENTIAL

OBSERVERS

Mr. Fred Fischer	-	Ordnance Tank - Automotive Command Detroit Arsenal Center Line, Michigan ORDMX - RC.2
Mr. F. C. Penny	-	Rheem Manufacturing Company Lester Pennsylvania

CONFIDENTIAL

<u>NAME AND ADDRESS</u>	<u>DISTRIBUTION</u>	<u>NO. OF COPIES</u>	<u>COPY NO.</u>
Chief of Ordnance Department of the Army Washington 25, D. C. ATTN: ORDTT ORDTX-AR		1 1	3 4
Commanding Officer Detroit Arsenal Center Line, Michigan ATTN: ORDMC-RC ORDMC-RM		1 1	5 6
Commanding Officer Frankford Arsenal Bridesburg Station Philadelphia 37, Pa. ATTN: Pitman-Dunn Lab		1	7
Commanding Officer Watertown Arsenal Watertown 72, Mass. ATTN: ORDBE-L		1	8
President CONARC Board No. 2 Fort Knox, Kentucky THRU: CONARC Liaison Officer Aberdeen Proving Ground, Md.		1	9
CONARC Liaison Officer Aberdeen Proving Ground, Md.		1	10
Armed Services Technical Information Agency Knott Building Document Service Center Dayton, Ohio		1 vellum	11
Rheem Manufacturing Company Lester, Pennsylvania Pittsburgh Ordnance District		1	12
Technical Library Branch Aberdeen Proving Ground Maryland		Original Reference Copy Record Copy	0 1 2

CONFIDENTIAL

7

APPENDIX A

ORDTT-CVS-3
OO/5C-23500

2d Ind (C)

RSBoone/gac/53749

SUBJECT: Ballistic Test of Oscillating Turrets - T77 (U)

APG(C) 451.6/62

DA, ORD O, Washington 25, D. C., 5 December 1955

TO: CG, Aberdeen Proving Ground, Maryland

1. It is requested that ballistic tests of 120-mm oscillating turrets be conducted as outlined in basic letter, with the exception that tests should be limited to those necessary for evaluation of those aspects that are peculiar to the oscillating type turret.

2. Charges for this work should be made against Project TTL-5, Priority 1C.

BY COMMAND OF MAJOR GENERAL CUMMINGS:

7

1 Incl
n/c

CC: CG, Ord Tank-Autmv Comd
(Attn: ORDMX-ECMB)

H. N. BROWNSON
Lt Col, Ord Corps
Assistant
/s/
J. F. SHAWALTER
Lt Col, Ord Corps
Assistant

REGRADING DATA CANNOT BE PREDETERMINED

4

A-1

CONFIDENTIAL

CONFIDENTIAL

3

Ordnance Corps (S7) 00/50 23500
DETROIT ARSENAL 470.4/Det.Ars.
2851 VAN DYKE AVENUE (19 Oct 55)C
CENTER LINE, MICHIGAN
PHONE JEFFERSON 6-5000

IN REPLY Dars. 470.4/OCO(19 Oct 55)C AHFisher/was/24-106

REFER TO ORDMX-ECMB

APG(C) 451.6/62

OCT 19 1955

SUBJECT: Ballistic Test of Oscillating Turrets -- T-77 (U)

THRU: Commanding General
Ordnance Tank-Automotive Command
1501 Beard
Detroit 9, Michigan

TO: Chief of Ordnance
Department of the Army
Washington 25, D. C.
ATTENTION: ORDTT-CVS-3

1. Based on the results of firings on the T-69 oscillating turrets as reported in Aberdeen Proving Ground Armor Test Report #AD-1186, The Rheem Manufacturing Company, Incorporated has designed a new oscillating turret (T-77). This new turret incorporates the recommendations of the Proving Ground to provide improved ballistics and increased fragment resistance. At the present time two(2) T-77 turrets are at the Proving Ground awaiting test.

2. A vulnerability determination of these turret bodies at various attack conditions is recommended with firings to be conducted with the following ammunition: 90mm AP shot, T33; 90mm HVAP projectile, M304; 76mm AP shot, T128E6; and caliber .50 AP bullet, M2. It is suggested that the Proving Ground compare the T77 with the T69 model and determine the minimum number of firings which will present an adequate ballistic analysis of this turret.

3. The following outline is suggested for the tests employing 90mm projectiles:

a. Attack frontally in the running position. Fire at exposed side areas and armor around gun.

b. Attack 30 degrees from longitudinal axis in running position - fire at all exposures presented by turret sides from both right and left flank attack.

4. The following outline is suggested for the tests employing 75mm AP projectiles:

REGRAIDING DATA CANNOT BE PREDETERMINED

A-2

CONFIDENTIAL

CONFIDENTIAL

ORDMX-ECMB

SUBJECT: Ballistic Test of Oscillating Turrets — T-77(U) OCT 19 1955

a. Attack 60 degrees from the longitudinal axis in running position - fire at all exposures presented by turret sides from both flanks.

b. Attack 90 degrees from longitudinal axis in running position - fire as in paragraph 4a.

5. Inasmuch as the T69 turrets were very vulnerable in the trunion area, it is suggested that these areas be subjected to 90mm AP projectile impacts.

6. It is also suggested that the clearances between the ring area and the turret area be again tested for splash and keying to determine whether the deficiencies have been improved over the earlier versions.

7. In this particular test only two (2) turrets have been submitted for tests; it is, therefore, recommended that the maximum number of tests with the minimum number of rounds be conducted.

8. Sufficient notification to all interested parties shall be given by the Proving Ground in order that observers may be present.

9. The recommended time for completion of this test is 90 days after receipt of directive. The number of progress reports to be prepared should be determined by the Proving Ground. The final report should be distributed in accordance with the attached list. However, if Office, Chief of Ordnance so chooses, any additions or deletions may be made at their discretion.

10. If clarification or expansion of this program is desired, it is recommended that further communication with this Arsenal be initiated. The details concerning the actual rounds to be fired or the number of ballistic limits to be determined shall be made by the Proving Ground. Upon completion of all ballistic tests, this Government property may be disposed of in accordance with existing regulations.

FOR THE COMMANDING OFFICER:

(J2)

(s)

J. B. HAYES
Assistant

1 Incl

1. Proposed Distribution List

CC

Aberdeen Prov Ground

ATTN: ORDEG-DP-TT

Mr. W. C. Fless

2

REGARDING DATA CANNOT BE PREDETERMINED

A-3

CONFIDENTIAL

CONFIDENTIAL

00/5C 23500

3

(S7)

18361

ORDMC-R

1st Ind (U)

DARS 470.4/OCO(19 Oct 55)C

SUBJECT: Ballistic Test of Oscillating Turrets -- T-77 (U)

470.4/Det Ars (19 Oct 55)C

Hq, Ordnance Tank-Automotive Command, 1501 Beard, Detroit 9, Michigan

25 October 1955

APG(C) 451.6/62

TO: Chief of Ordnance, Dept of the Army, Washington 25, D. C.

ATTN: ORDTT-CVS-3

Outline of ballistic test of T-77 is forwarded for concurrence and appropriate action.

FOR THE COMMANDING GENERAL:

3

/s/

(S7)

1 Incl

n/c

J. A. FINKEL

Colonel, Ord Corps

Assistant

3

REGARDING DATA CANNOT BE PREDETERMINED

A-4

CONFIDENTIAL

(A6)

HEADQUARTERS
ORDNANCE TANK-AUTOMOTIVE COMMAND
DETROIT ARSENAL
28251 VAN DYKE AVENUE
CENTER LINE, MICHIGAN

HSpiro/bg/24-106

OTAC 400.112/Aberdeen Proving Ground
IN REPLY
REFER TO
(16 Aug 56)

ORDMC-RM.1

16 August 1956

APG 470.5/182(1956)

SUBJECT: Ballistic Testing of Oscillating Turret T 77

TO: Commanding General
Aberdeen Proving Ground
Aberdeen, Maryland

ATTENTION: ORDBG-DP-TT, Mr. W. Fless

Due to the lack of funds at this Command, the Ballistic Testing of Oscillating Turret T 77 program should be terminated. It is requested that the oscillating turret castings located at Aberdeen Proving Ground be disposed of in accordance with AR 380-5.

FOR THE COMMANDER:

/s/

JOHN P. JONES
Assistant

CC
ORDMC-RC.2

CONFIDENTIAL

ENGINEERING LABORATORIES
PHYSICAL TEST LABORATORY REPORT

APPENDIX B

ORDEG-DP-LP

TEST OF:

Two (2) Oscillating Tank
Turrets, T77, Serial Nos. 1 and 3.

OBJECT OF TEST:

To obtain the wall thickness
of the above turrets before test
at APG.

TEST PROCEDURE:

1. Instrumentation:
Reflectoscope and calipers.
2. Procedure:

a. The turrets were marked off in approximately 10" x 10" sections
and numbered (see APG Photographs B14480 thru 14485, Appendix II).

b. The calipers were used in obtaining the wall thickness where
possible. The remaining measurements required a smooth spot to be ground
as close to the center of each section as surface conditions would permit
so measurements could be taken with the reflectoscope. One measurement was
obtained in each block.

c. Sections 169 to 196 inclusive, are located on the skirt, and
due to the contour, exact maximum thickness measurements could not be obtained.
Thicknesses in these sections should be considered as approximate.

d. Sections with letter "A" preceding number are located behind
skirt and a continuation of corresponding number in photos.

RESULTS:

1. For data see Appendix I.
2. For Photographs see Appendix II.

2 Incls.
Appendix I
Appendix II

Approved: J. M. McKinley
J. M. McKinley,
Chief,
Physical Test Laboratory.

Signed: James W. Hornberger, Jr.
James W. Hornberger, Jr.
Measurements
Branch.
H.J.

CONFIDENTIAL

ORDBG-DP-LP

Report No. 56-L-26
Sheet 1 of 4

Thickness Measurements of Oscillating Tank Turret, No. 1

<u>Section No.</u>	<u>Thickness</u>	<u>Section No.</u>	<u>Thickness</u>	<u>Section No.</u>	<u>Thickness</u>
1	6.22"	36	5.70"	71	3.50"
2	3.52	37	6.25	72	3.55
3	2.50	38	3.00	73	3.75
4	2.55	39	6.30	74	3.45
5	2.35	40	6.60	75	3.80
6	2.55	41	4.00	76	3.60
7	3.00	42	6.40	77	3.00
8	4.65	43	3.00	78	3.00
9	3.75	44	5.60	79	2.75
10	2.05	45	3.00	80	2.70
11	2.05	46	3.00	81	2.80
12	2.05	47	6.70	82	3.00
13	2.05	48	3.00	83	3.00
14	1.75	49	7.80	84	8.55
15	2.75	50	4.25	85	2.40
16	4.16	51	6.00	86	2.50
17	4.60	52	3.00	87	2.60
18	2.10	53	6.55	88	2.60
19	1.90	54	4.20	89	3.00
20	1.60	55	3.40	90	10.10
21	1.90	56	2.00	91	2.80
22	3.40	57	3.25	92	2.65
23	4.40	58	3.10	93	2.60
24	5.25	59	3.25	94	2.30
25	3.05	60	3.35	95	3.00
26	1.75	61	2.70	96	10.70
27	1.50	62	2.25	97	2.80
28	2.25	63	2.45	98	2.40
29	4.00	64	8.55	99	2.65
30	5.75	65	3.25	100	2.80
31	5.75	66	3.05	101	3.10
32	5.60	67	3.20	102	10.50
33	4.30	68	3.40	103	2.70
34	5.30	69	3.30	104	2.50
35	5.30	70	3.20	105	2.60

(Appendix I)

B-2

CONFIDENTIAL

CONFIDENTIAL

ORDG-DP-LP

Report No. 56-I-26
Sheet 2 of 4

<u>Section No.</u>	<u>Thickness</u>	<u>Section No.</u>	<u>Thickness</u>	<u>Section No.</u>	<u>Thickness</u>
106	2.60"	136	2.10"	166	2.40"
107	2.70	137	2.10	167	2.30
108	10.30	138	2.80	168	2.25
109	2.80	139	2.70	169	3.20
110	2.60	140	3.23	170	3.00
111	2.40	141	2.95	171	3.30
112	2.45	142	3.10	172	3.30
113	2.85	143	3.35	173	3.00
114	10.05	144	3.45	174	3.20
115	2.65	145	3.10	175	6.40
116	2.25	146	3.45	176	8.00
117	2.60	147	2.45	177	6.60
118	2.85	148	3.30	178	8.30
119	2.75	149	6.30	179	8.00
120	9.15	150	9.15	180	5.00
121	2.70	151	10.05	181	3.30
122	2.30	152	10.30	182	3.00
123	2.00	153	10.50	183	3.25
124	2.10	154	10.70	184	3.00
125	3.05	155	10.10	185	4.60
126	2.90	156	2.65	186	3.00
127	8.75	157	2.65	187	3.80
128	8.75	158	2.50	188	4.40
129	2.52	159	2.50	189	5.60
130	2.10	160	1.95	190	8.10
131	2.85	161	1.90	191	3.40
132	2.20	162	1.85	192	6.60
133	3.00	163	2.45	193	6.15
134	3.50	164	2.40	194	4.60
135	2.60	165	2.45	195	5.15
				196	4.15

Behind Skirt

<u>Section No.</u>	<u>Thickness</u>
Front	
34 A	5.20"
36 A	5.45
38 A	4.40
41 A	5.90
43 A	3.90
45 A	3.65
46 A	3.05
51 A	4.00
52 A	3.95
53 A	4.95

(Appendix I)
B-3

CONFIDENTIAL

CONFIDENTIAL

ORDEG-DP-LP

Report No. 56-L-26
Sheet 3 of 4

<u>Section No.</u>	<u>Back</u>	<u>Thickness</u>
77 A		3.05"
78 A		3.10
85 A		2.55
91 A		2.80
97 A		2.85
103 A		2.80
109 A		2.70
115 A		2.65
141 A		3.00
146 A		3.40

Serial No. 3							
<u>Section No.</u>	<u>Thickness</u>	<u>Section No.</u>	<u>Thickness</u>	<u>Back Section No.</u>	<u>Thickness</u>	<u>Front Section No.</u>	<u>Thickness</u>
151	10.20"	181	3.25"	77 A	3.60"	34 A	5.60"
152	10.25	182	3.00	78 A	3.30	36 A	5.80
153	10.30	183	5.00	85 A	3.10	38 A	4.40
154	9.70	184	3.40	91 A	2.80	41 A	4.90
155	9.95	185	4.70	97 A	2.75	43 A	4.00
156	2.80	186	3.10	103 A	2.50	45 A	3.90
157	2.80	187	3.40	109 A	2.65	46 A	3.00
158	2.75	188	5.60	115 A	2.60	51 A	4.05
159	2.60	189	7.00	141 A	2.95	52 A	4.15
160	2.05	190	5.80	146 A	4.00	53 A	5.20
161	2.00	191	8.70				
162	2.00	192	8.00				
163	1.45	193	7.00				
164	1.45	194	6.00				
165	1.40	195	7.60				
166	2.35	196	3.35				
167	1.35						
168	2.44						
169	7.20						
170	3.20						
171	3.00						
172	3.35						
173	3.20						
174	3.35						
175	7.30						
176	10.40						
177	5.50						
178	5.75						
179	10.95						
180	5.50						

B-4

(Appendix I)

CONFIDENTIAL

ORDBG-DP-LP

Report No. 56-L-26
Sheet 4 of 4

Thickness Measurements, Oscillating Tank Turret, T77
Rheem, Serial No. 3

Section No.	Thickness	Section No.	Thickness	Section No.	Thickness	Section No.	Thickness		
1	4.20"	31	5.50"	61	2.54"	91	2.75"	121	3.00"
2	2.90	32	5.30	62	2.05	92	2.55	122	2.60
3	2.30	33	6.85	63	2.10	93	2.40	123	3.00
4	2.45	34	5.80	64	8.55	94	2.50	124	2.45
5	2.50	35	6.00	65	3.50	95	2.55	125	3.05
6	2.55	36	6.00	66	3.25	96	9.70	126	3.00
7	2.85	37	6.70	67	3.20	97	2.60	127	7.00
8	5.00	38	3.50	68	3.05	98	2.40	128	9.95
9	3.50	39	7.00	69	3.15	99	2.40	129	2.60
10	2.00	40	6.95	70	3.30	100	2.50	130	2.15
11	1.80	41	4.80	71	3.40	101	2.60	131	3.25
12	1.80	42	7.00	72	3.70	102	10.30	132	2.20
13	2.00	43	3.00	73	3.60	103	2.55	133	3.15
14	1.75	44	5.60	74	3.50	104	2.50	134	3.95
15	2.80	45	3.00	75	3.80	105	2.45	135	2.60
16	4.30	46	4.00	76	3.40	106	2.60	136	2.40
17	3.90	47	5.40	77	3.65	107	2.65	137	2.50
18	2.20	48	3.25	78	3.25	108	10.25	138	2.90
19	2.05	49	6.10	79	3.15	109	2.60	139	3.10
20	1.65	50	5.20	80	2.85	110	2.00	140	3.35
21	1.95	51	6.00	81	2.70	111	2.00	141	3.00
22	3.30	52	3.70	82	3.00	112	2.60	142	3.50
23	4.35	53	6.35	83	3.20	113	2.45	143	3.90
24	5.35	54	6.65	84	8.55	114	10.20	144	3.30
25	3.05	55	3.27	85	3.10	115	2.60	145	2.45
26	1.95	56	2.06	86	3.05	116	2.35	146	3.00
27	1.75	57	2.91	87	2.50	117	2.40	147	2.45
28	2.45	58	2.91	88	2.70	118	3.00	148	3.85
29	3.55	59	3.01	89	2.80	119	2.65	149	6.45
30	7.00	60	2.64	90	9.95	120	9.55	150	9.55

Appendix I

CONFIDENTIAL

APPENDIX C

T77 OSCILLATING TURRET

Serial No. 1

PHASE I

MK 2 Fragmentation Grenade - Lot No. IS-SR-7

Grenade No. 2 - Grenade placed on dividing line of Areas 177 and 178 on skirting ring directly under gun shield opening. Turret at 0° Elevation. Foil completely destroyed.

Grenade No. 2 -- Grenade placed on dividing line of Areas 177 and 178 on skirting ring directly under gun shield opening. Turret at maximum elevation. Foil completely destroyed.

Grenade No. 3 - Grenade placed on dividing line of Areas 115 and 121 on skirting ring on the Right Rear Side of Turret under bustle. Foil completely destroyed.

PHASE II

37mm H. E. M54 Splash Test

Round No. 1 - Hit on the dividing line of Areas 42 and 44 on the center line of turret directly beneath the gun shield opening. Turret at 0° obliquity - Foil completely destroyed.

Round No. 2 - Hit on dividing line of Areas 43 and 45 on the center line of turret directly beneath the gun shield opening. Turret in maximum elevation. Foil completely destroyed.

PHASE III

Caliber .50 AP M2 Keying Test

Round No. 1 - Hit in Lower Right corner of Area 43 directly under gun shield opening. Some petalling - No hindrance to turret movement.

Round No. 2 - Hit in lower left corner of Area 45 directly under gun shield opening. Some petalling - No hindrance to turret movement.

Round No. 3 - Hit in Lower Left corner of Area 54 - 90° Flank Attack. Some petalling and cratering. No hindrance to turret movement.

Round No. 4 - Hit in Lower Right corner of Area 54 - 90° Flank attack - some petalling - No hindrance to turret movement.

Round No. 5 - Disregard.

Round No. 6 - Fired from a direct frontal attack on the left side straight into the opening between the Trunnion Face on the turret and skirting ring - Small fragment lodged in this opening. No damage to mobility of turret.

CONFIDENTIAL

Round No. 7 - Disregard.

Round No. 8 - Fired from a direct rear attack on the Right Side straight into the opening between the trunnion face on the turret and skirting ring. Projectile wedged between machined face on skirting ring and into same surface on turret. Draw bar strain gauge reading 7484 lbs pull to move turret; 6073 lbs. pull required to move turret with projectile cut out.

PHASE IV

Direct Frontal Attack - Right Side

90mm AP T33E7

* Rd. No. 1 Velocity 3056 fps Partial Penetration

Hit at junction of Areas 24, 25, 30, 39. Average Thickness - 5.08".
Scoop on face 8 1/4" x 6". - No face cracks - Rear surface Slight Bulge.
2 1/2" Horizontal crack - Two 3/4" vertical cracks.

* Rd. No. 2 Velocity 3059 fps Complete Penetration

Hit in Area 24. Average thickness = 5.25". Scoop on face 9" x 6 1/2".
No face cracks - Rear surface - medium bulge 3" Horizontal crack - 1" Vertical crack - 3/4" x 3/4" Back spall displaced.

* Protection Ballistic Limit = 3058 fps. using Rounds 1 and 2 based on an average thickness of 5.17".

PHASE V

30° Front Attack - Left Side

90mm AP T33E7 Projectile

Rd. No. 3 Velocity 3069 fps. Complete Penetration

Hit in Area 23. Average thickness = 4.40". Scoop on face 8 1/4" x 6".
Opening on face 4" x 3 3/4". No face cracks - Rear surface ED 5 13/16" x 4 1/8".
Pun. O. 4 3/8" x 3 11/16" - No cracks.

Rd. No. 4 Velocity 2867 fps. Complete Penetration

Hit on dividing line of Areas 29 and 49. Average thickness = 5.90".
Scoop on face 8 1/8" x 6 1/4". Projectile-in-plate. Rear surface - Exit diameter 5" x 4 7/8" - No cracks.

Rd. No. 5 Velocity 2638 fps. Partial Penetration

Hit on dividing line of Areas 22 and 29. Average thickness = 3.70".
Scoop on face 7 1/4" x 5". No face cracks - Rear surface - Medium bulge.
No cracks.

CONFIDENTIAL

Rd. No. 6 Disregard

* Rd. No. 7 Velocity 2819 fps. Complete Penetration

Hit in Area 22. Average thickness = 3.40". Scoop on face 9 1/2" x 4". Opening on face 4" x 3 1/2". No face cracks. Rear surface - Exit diameter 5 9/16" x 4 1/2". Punching Out 4" x 3". No cracks.

Rd. No. 8 - Disregard

* Rd. No. 9 Velocity 2752 fps. Partial Penetration

Hit on dividing line of Areas 21 and 28. Average thickness = 2.08". Scoop on face 15" x 4". No face cracks. Rear surface - Large Bulge. 9 1/2" Vertical crack.

* Protection Ballistic Limit = 2786 fps. using Rds. No. 7 and 9. Based on an average thickness of 2.74".

The following two rounds were fired into the same general area to confirm the above Ballistic Limit.

Rd. No. 10 Velocity 2823 fps. Complete Penetration

Hit in Area 16. Average thickness = 4.16". Scoop on face 8 1/4" x 5 3/4". Opening on face 4 1/4" x 4". No face cracks - Rear surface - Exit diameter 4 1/2" x 4 3/8". Punching Out 4 1/8" x 3 1/4". No cracks.

Rd. No. 11 Velocity 2735 fps. Partial Penetration

Hit in Area 15. Average thickness = 2.75". Scoop on face 10 3/4" x 3 7/8". No face cracks - Rear surface - Slight bulge, No cracks.

PHASE VI

Direct Frontal Attack - Under Gun Shield Opening

90mm AP T33E7 Projectile

Turret at Maximum Elevation

Rd. No. 12 Velocity 2279 fps. Partial Penetration

Hit on dividing line between Areas 45 and 46. Average thickness = 3.00". Scoop on face 10" x 7". No face cracks. Rear surface - Medium bulge - 3" Vertical crack - Numerous hair cracks - Projectile fragments lodged between turret and skirting ring. Drawbar strain gauge reading of 9375 lbs. failed to move turret.

Rd. No. 13 Velocity 2315 fps. Complete Penetration

Hit in Area 45. Average thickness = 3.00". Scoop on face 8" x 5". Petalling extending 2" overlapping skirting ring. Impossible to depress turret - Projectile in plate - Rear surface - Punching Out 5 1/2" x 5" - No cracks on rear.

CONFIDENTIAL

Rd. No. 14 Velocity 2228 fps. Complete Penetration

Hit in Area 42. Average thickness = 6.40". Scoop on face 6 1/4" x 5".
Opening on face 5" x 3 1/4". Petalling extends 2" overlapping skirting ring.
Impossible to depress turret - Rear surface - Exit diameter 6" x 5 13/16".
Punching Out 3 1/2" x 3 1/2" - No cracks on rear.

Rd. No. 15 Velocity 2093 fps. Partial Penetration

Hit in Area 41. Average thickness = 4.00" Scoop on face 6 1/4" x 4 1/2".
Petalling extends 3 1/2" overlapping skirting ring. Impossible to depress
turret. - Rear surface - Large Bulge "Y" crack 7" x 2 1/2".

* No Protection Ballistic Limit obtained - Low complete penetration =
2228 fps.

PHASE VII

90° Flank Attack - Left Side

90mm AP T33E7 Projectile

Rd. No. 16 Velocity 3072 fps. Partial Penetration

Hit in Area 182. Average thickness = 3.00". Scoop on face 8" x 5 1/4".
Spatter on turret - No damage to movement of turret.

Rd. No. 17 Velocity 2004 fps. Partial Penetration

Hit on left trunnion cap. Scoop 11 3/4" x 6 1/2" - Part of Trunnion
cap displaced - Turret locked in position - oil leak around trunnion nut
on interior of turret.

PHASE VIII

90° Flank Attack - Right Side

90mm AP T33E7 Projectile

Rd. No. 18 Velocity 2007 fps. Partial Penetration

Hit on right trunnion cap. Scoop 7" x 5 1/2". Turret immobilized -
No damage on interior.

CONFIDENTIAL

PHASE IX

60° Flank Attack - Right Side - on Bustle

76mm AP TL28E6 Projectile

Rd. No. 1 Velocity 2508 fps. Partial Penetration

Hit on dividing line of Areas 145 and 148. Average thickness = 3.20".
Scoop on face 9 1/4" x 4". No face crack - Rear Surface - Slight bulge -
No cracks.

Rd. No. 2 Velocity 2675 fps. Partial Penetration

Hit on dividing line of Areas 136 and 139. Average thickness - 2.40".
Scoop on face 10" x 3 1/2". No face crack - Rear surface - Medium bulge -
2" x 1 1/2" back spall displaced.

* Rd. No. 3 Velocity 2624 fps. Partial Penetration

Hit in Area 143. Average thickness = 3.35". Scoop on face 9 1/2" x 4".
No face cracks - Rear surface - Slight bulge - no cracks.

* Rd. No. 4 Velocity 2628 fps. Complete Penetration

Hit on dividing line of Areas 137 and 140. Average thickness - 2.78".
Scoop on face 10 1/4" x 3 1/2". No face cracks - Rear surface - Punching
Out 3" x 2".

Rd. No. 5 Velocity 2596 fps. Partial Penetration

Hit in Area 133. Average thickness = 3.00". Scoop on face 9 1/2" x
3 3/4". No face cracks. - Rear surface - Slight bulge. No cracks.

*Protection Ballistic Limit = 2626 fps. using Rounds 3 and 4 based on an
average thickness of 3.04".

PHASE X

90° Flank Attack - Left Side

76mm AP TL28E6 Projectile

Rd. No. 1 - Disregard

* Rd. No. 2 Velocity 1519 fps. Partial Penetration

Hit on dividing line of Areas 65 and 71. Average thickness = 3.38".
Scoop on face 3" x 3". No face cracks - Rear surface - Medium bulge -
One 1/2" crack.

CONFIDENTIAL

* Rd. No. 3 Velocity 1586 fps. Complete Penetration

Hit in Area 66. Average thickness = 3.05" - Projectile struck in face -
Rear surface - Punching Out 2 1/2" x 2 1/2".

Rd. No. 4 Velocity 1506 fps. Partial Penetration

Hit in Area 72. Average thickness = 3.55". Scoop on face 3" x 3". No
face cracks - Rear surface - Medium bulge. 3 1/2" vertical crack.

* Protection Ballistic Limit = 1553 fps. using Rounds 2 and 3 based on
an average thickness of 3.22".

PHASE XI

90° Flank Attack- Right Side - 76mm AP T128E6 Projectile

* Rd. No. 1 Velocity 1406 fps. Partial Penetration

Hit on dividing line of Areas 142 and 145. Average thickness = 3.10".
Scoop on face 3" x 3". No face cracks - Rear surface - Medium bulge.
"Y" Crack 1" x 1 3/4" x 2 1/2".

* Rd. No. 2 Velocity 1446 fps. Complete Penetration

Hit on dividing line of Areas 142 and 145. Average thickness = 3.10".
Scoop on face 3" x 3". No face cracks - Rear surface - Medium bulge. Large
crack 4" long 3/4" wide. Fragments displaced.

* Protection Ballistic Limit = 1426 fps. using Rounds 1 and 2 based on
an average thickness of 3.10".

PHASE XII

60° Flank Attack - Left Side

76mm AP T128E6 Projectile

Rd. No. 1 Velocity 2671 fps. Partial Penetration

Hit on dividing line of Areas 68 and 74. Average thickness = 3.43".
Scoop on face 7 5/8" x 4 1/2". No face cracks - Rear surface - Medium bulge
4" Crack.

Rd. No. 2 Velocity 2806 fps. Partial Penetration

Hit on dividing line of Areas 67 and 68. Average thickness = 3.30".
Scoop on face 8 1/4" x 4 1/2". No face cracks - Rear surface - Medium bulge.
"X" Crack 1" x 2".

Rd. No. 3 Velocity 2859 fps. Partial Penetration

Hit in Area 69. Average thickness = 3.30". Scoop on face 9" x 4 1/2".
No face cracks - Rear surface - Small bulge. No cracks.

CONFIDENTIAL

Rd. No. 4

Velocity 3049 fps

Partial Penetration

Hit on dividing line of Areas 68 and 69. Average thickness = 3.35".
Scoop on face 8 3/4" x 5". No face cracks - Rear surface - Medium bulge.
Irregular shaped crack 2 3/4".

Rd. No. 5

Velocity 2682 fps

Partial Penetration

Hit on dividing line of Areas 69 and 70. Average thickness = 3.25".
Scoop on face 9 1/2" x 4 1/2". No face cracks - Rear surface - Medium
bulge - 4" Crack.

Rd. No. 6

Velocity 2653 fps

Partial Penetration

Hit in Area 68. Average thickness = 3.40". Scoop on face 9 1/2" x
4 1/4". No face cracks - Rear surface - Small Bulge. No cracks.

* No Protection Ballistic Limit obtained. High partial penetration =
3049 fps. based on an average thickness of 3.35".

CONFIDENTIAL

T77 OSCILLATING TURRET

SERIAL No. 3

PHASE I

MK2 FRAGMENTATION GRENADE - Lot No. IS-SR-7

Grenade No. 1 - Grenade was placed on the dividing line of Areas 177 and 178 on the skirting ring directly under the gun shield opening. Turret was at 0° elevation. Foil was completely destroyed.

Grenade No. 2 - Grenade was placed in the upper center portion of Area 176 on the skirting ring below and to the left of the gun shield opening. Turret was at 0° elevation. Foil was completely destroyed.

Grenade No. 3 - Grenade was placed on the dividing line of Areas 191 and 192 on the skirting ring below the rear portion of the turret under the bustle. Turret was at 0° elevation. Foil was completely destroyed.

PHASE II

37mm H. E. M54 - Splash Test

Rd. No. 1 - Hit at the lower intersection of Areas 42 and 44 on the turret directly beneath the gun shield opening. Turret was at 0° obliquity. Foil was completely destroyed.

Rd. No. 2 - Hit at the lower intersection of Areas 44 and 47 on the turret below and slightly to the right of the gun shield opening. Turret was at 0° elevation. Foil was completely destroyed.

PHASE III

Caliber .50 AP M2 - Keying Test

Rd. No. 1 - Hit in lower right corner of Area 43 directly beneath the gun shield opening. There was some petalling, but it did not hinder the turret movement. Turret was at maximum elevation.

Rd. No. 2 - Hit in lower center portion of Area 45 directly beneath the gun shield opening. There was some petalling, but not enough to hinder the movement of the turret. Turret was at maximum elevation.

Rd. No. 3 - Disregard

Rd. No. 4 - Disregard

CONFIDENTIAL

Rd. No. 5 - Hit in lower right corner of Area 54 - 90° flank attack on the left side of the turret. There was some petalling, but not enough to hinder the movement of the turret.

Rd. No. 6 - Fired from a direct rear attack on the right side straight into the opening between the trunnion face on the turret and skirting ring. The projectile wedged between the machined faces on the skirting ring and turret. Drawbar strain gauge reading of 9450 pounds pull to move the turret. After the projectile was removed, 6375 pounds of pull was required to move the turret.

PHASE IV

Direct Frontal Attack - Right Side

90mm HVAP M304

* Rd. No. 1 Velocity 3513 fps Partial Penetration

Hit in left side of Area 24. Average thickness = 5.35". Scoop on face 11 1/2" x 5 1/2". No face cracks. Rear surface - medium bulge. No cracks.

* Rd. No. 2 Velocity 3515 fps Complete Penetration

Hit on line between Areas 24 and 25. Average thickness = 3.05". Scoop on face 11 7/8" x 6" - entrance diameter = 3 1/2" x 3". Rear surface - punching effect 4 1/2" x 3 1/4".

Rd. No. 3 - Disregard

* Protection Ballistic limit = 3514 fps, using rounds 5 and 6 based on an average thickness of 4.20".

PHASE V

30° Front Attack - Left Side

90mm HVAP M304

* Rd. No. 1 Velocity 2895 fps. Complete Penetration

Average thickness = 2.45" - Scoop on face, 8" x 3", extended from the center to the upper left portion of Area 28 - four small face cracks about 1" in length - entrance diameter was 3 1/4" x 1 3/4". Exit diameter 4" x 2 7/8" - one 2" crack below exit hole.

CONFIDENTIAL

* Rd. No. 2 Velocity 2864 fps Partial Penetration

Average thickness = 3.55". Scoop on face, 7 1/4" x 3 3/4", hit upper portion of Area 29 - No face cracks - depth of penetration = 1 3/4". Rear surface - slight bulge with a Y-shaped crack not greater than 1" in length.

* Protection Ballistic limit = 2880 fps, using rounds 1 and 2 and based on an average thickness of 3.00".

PHASE VI

Direct Frontal Attack Under Gun Shield Opening

90mm HVAP M304

Turret at Maximum Elevation

Rd. No. 1 Velocity 2031 fps Complete Penetration

Hit in lower central portion of Area 45. Average thickness = 3.00". Scoop on face = 3" x 2 1/2" - entrance diameter = 2 1/4" x 1 3/4". Petalling on lower portion of entrance hole - No face cracks. Rear surface - petalling - exit diameter = 4 1/2" x 3 1/4". Front petalling permitted the turret to oscillate only 1/4 of an inch before being keyed to the skirting ring.

Rd. No. 2 Velocity 1925 fps Partial Penetration

Hit in the central portion of Area 42. Average thickness = 7". Scoop on face = 3 1/2" x 2 1/8" - entrance diameter 2 3/4" x 2 1/8" - petalling on lower portion of entrance hole. Nose of projectile broke and remained in the turret. Rear surface - medium bulge with cracks up to 3" in length. Front petalling permitted the turret to oscillate 6" before being keyed to the skirting ring.

Rd. No. 5 Velocity 1976 fps. Complete Penetration

Hit in lower left corner of Area 46. Average thickness = 4.00". Scoop on face = 3 3/4" x 3" - entrance diameter = 2 3/4" x 2" - petalling on lower right side of entrance hole - face cracking. Rear surface - exit diameter 2" x 2" - spalling area 4" x 3". Front petalling permitted the turret to oscillate 1 1/2" before being keyed to the skirting ring.

* No Protection Ballistic Limit obtained - Low complete penetration = 1976 fps.

CONFIDENTIAL

PHASE VII

30° FLANK ATTACK - LEFT SIDE

90mm AP T33E7

Rd. No. 1 Velocity 2011 fps. Partial Penetration

Hit in Area 183. Average thickness = 5.00". Scoop, 11 1/2" x 5 1/2", began at the left central portion of Area 183 and extended to the right till it affected the left cap by displacing it 1/2" outward from its original position. Depth of the scoop was 2". Both cap screws were sheared off. Oscillation of the turret was not hindered.

PHASE VII

30° FLANK ATTACK - RIGHT SIDE

90mm AP T33E7

Rd. No. 1 Velocity 2029 Partial Penetration

Hit in Area 171. Average thickness 3.00". Scoop, 11 7/8" x 5", began on right upper portion of Area 171 and extended to the right cap. Depth of scoop was 1 3/4". Oscillation of the turret was not hindered.

PHASE VIII

WOODEN WEDGE

One wooden wedge was placed by hand between the turret and skirting ring directly below the gun shield hole. The results proved that the wedge sufficiently keyed the turret and skirting ring and prevented oscillation.

CONFIDENTIAL

APPENDIX D

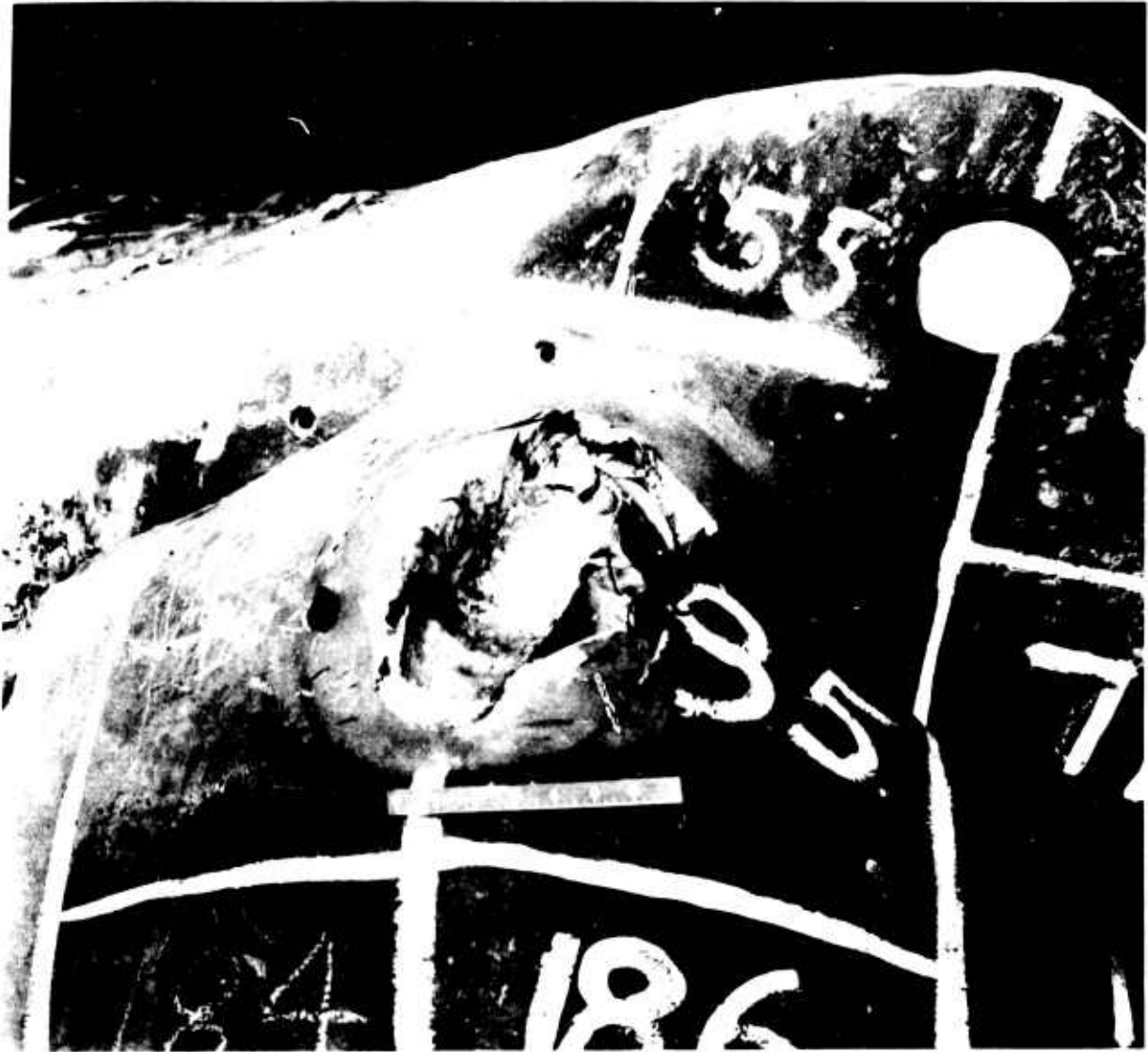


B18259: View of trunnion bearing cap on right side showing external damage after being attacked with a 90mm APT33 Projectile at a striking velocity of 2007 fps. Turret immobilized by impact.

D-1

CONFIDENTIAL

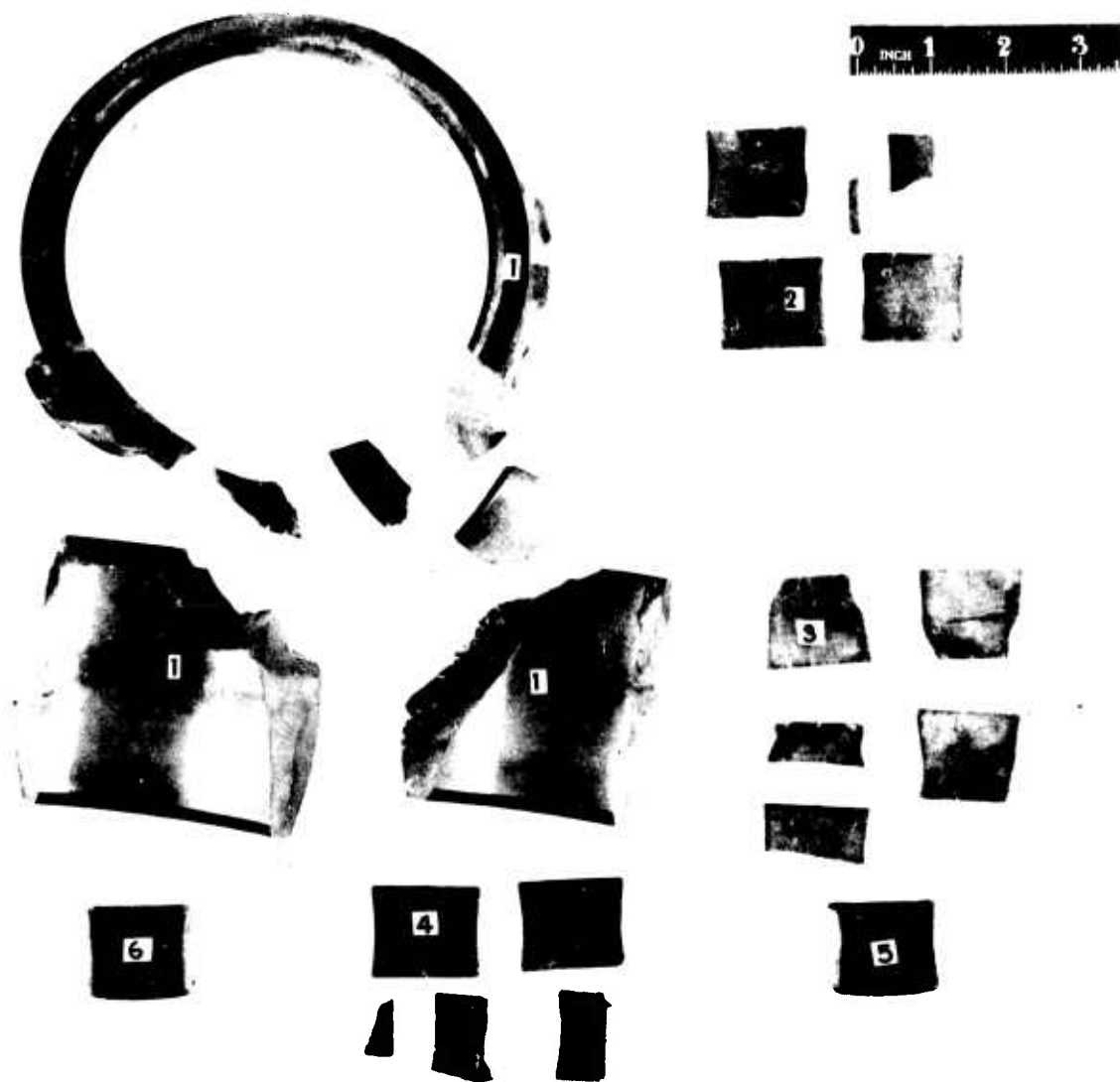
CONFIDENTIAL



B18260: View of trunnion bearing cap on left side showing external damage after being attacked with a 90mm APT33 Projectile at a striking velocity of 2004 fps. Turret immobilized by impact.

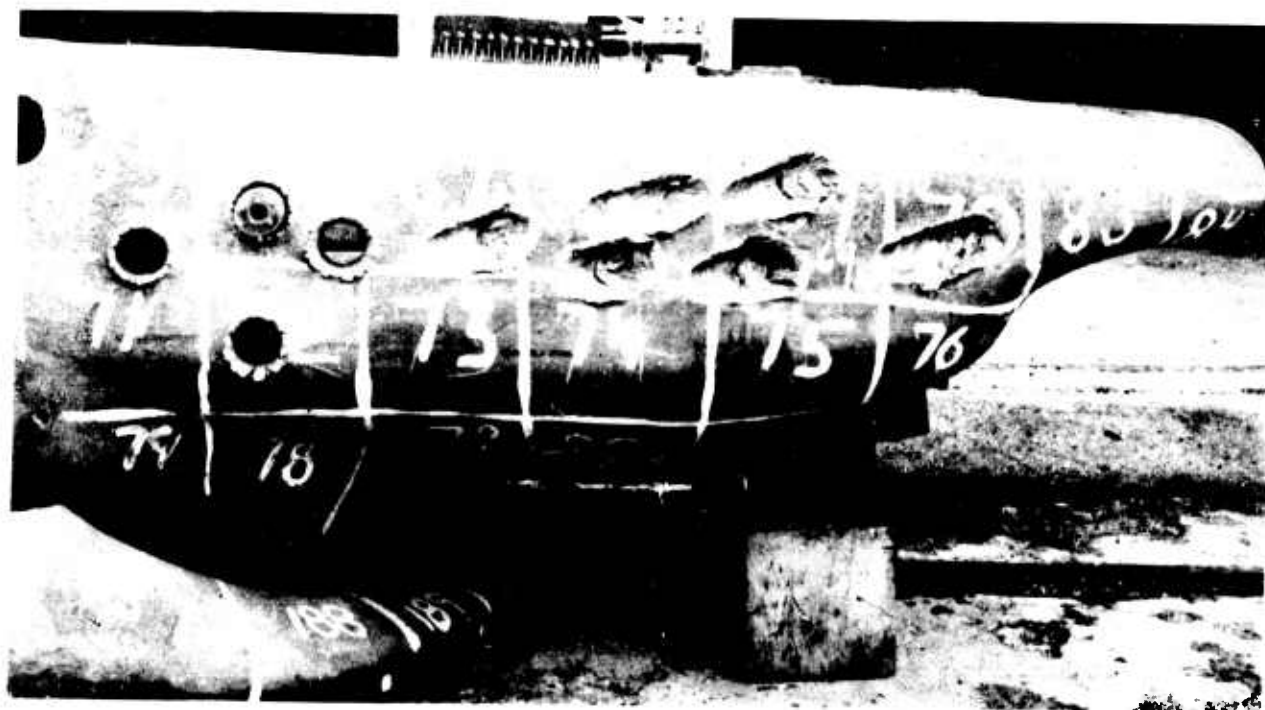
CONFIDENTIAL

CONFIDENTIAL



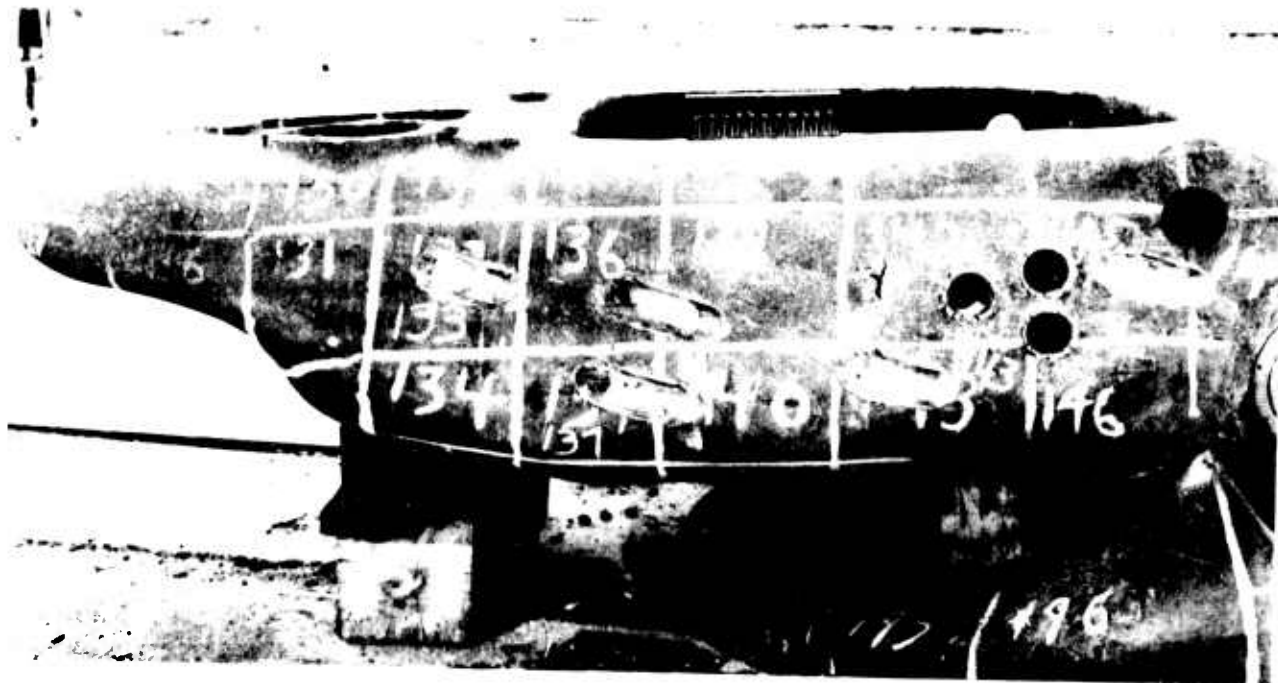
B18291: Photograph of interior damage to the left trunnion bearing after being impacted with one 90mm, AP, T33E7 Projectile at 2000 fps level. (1) Bearing race ring shattered on impact, (2-3-4) roller bearings shattered on impact, (5-6) roller bearing deformed on impact.

CONFIDENTIAL



B18538: Outside view of the left side of the turret (front) showing impact damage of ten 76mm AP T128E6 projectiles. Four 76mm AP projectiles were fired at 0° obliquity in sections 65, 66, 71 and 72. Hole in the lower right corner of section 66 was caused by a disregarded round. Six 76mm AP projectiles were fired at 60° obliquity in section 67, 68, 69, 70, 74 and 75.

CONFIDENTIAL

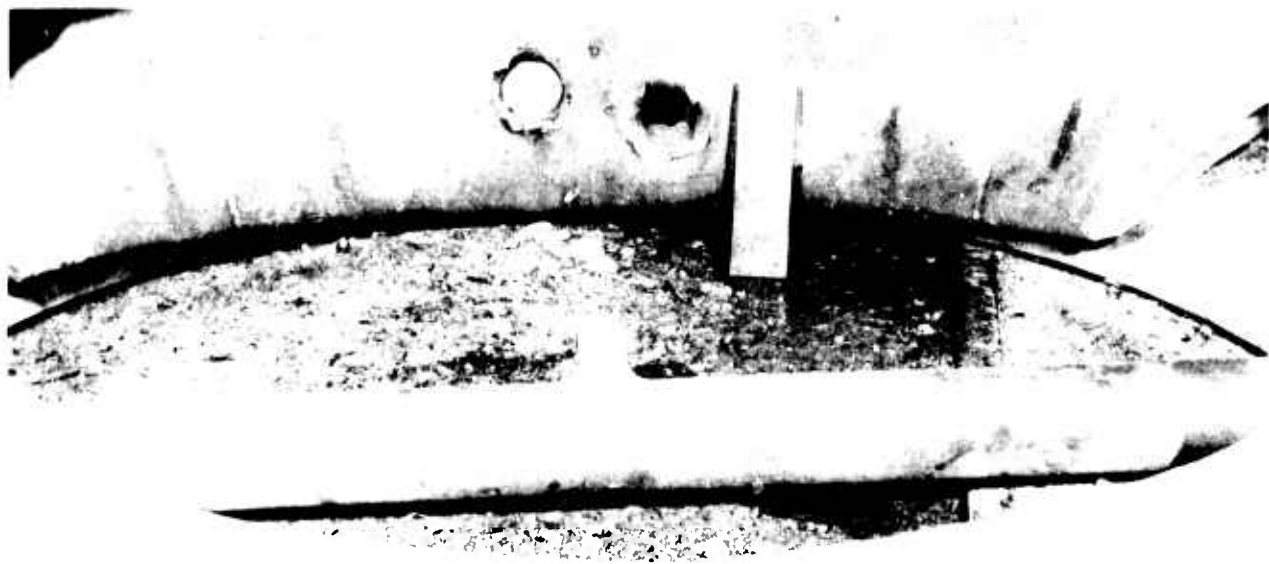


B18539: Outside view of the right side of the turret (front) showing impact damage of eight 76mm AP T128E6 projectiles. Three 76mm AP projectiles were fired at 0° obliquity in sections 142, 145 and 146. Five 76mm AP projectiles were fired at 60° obliquity in sections 133, 136, 137, 139, 140, 143, 145 and 148.

D-5

CONFIDENTIAL

CONFIDENTIAL



B18540: Effect of four 90mm AP, T33 projectile impacts from direct front below the gun shield of the turret. Interior view.

CONFIDENTIAL

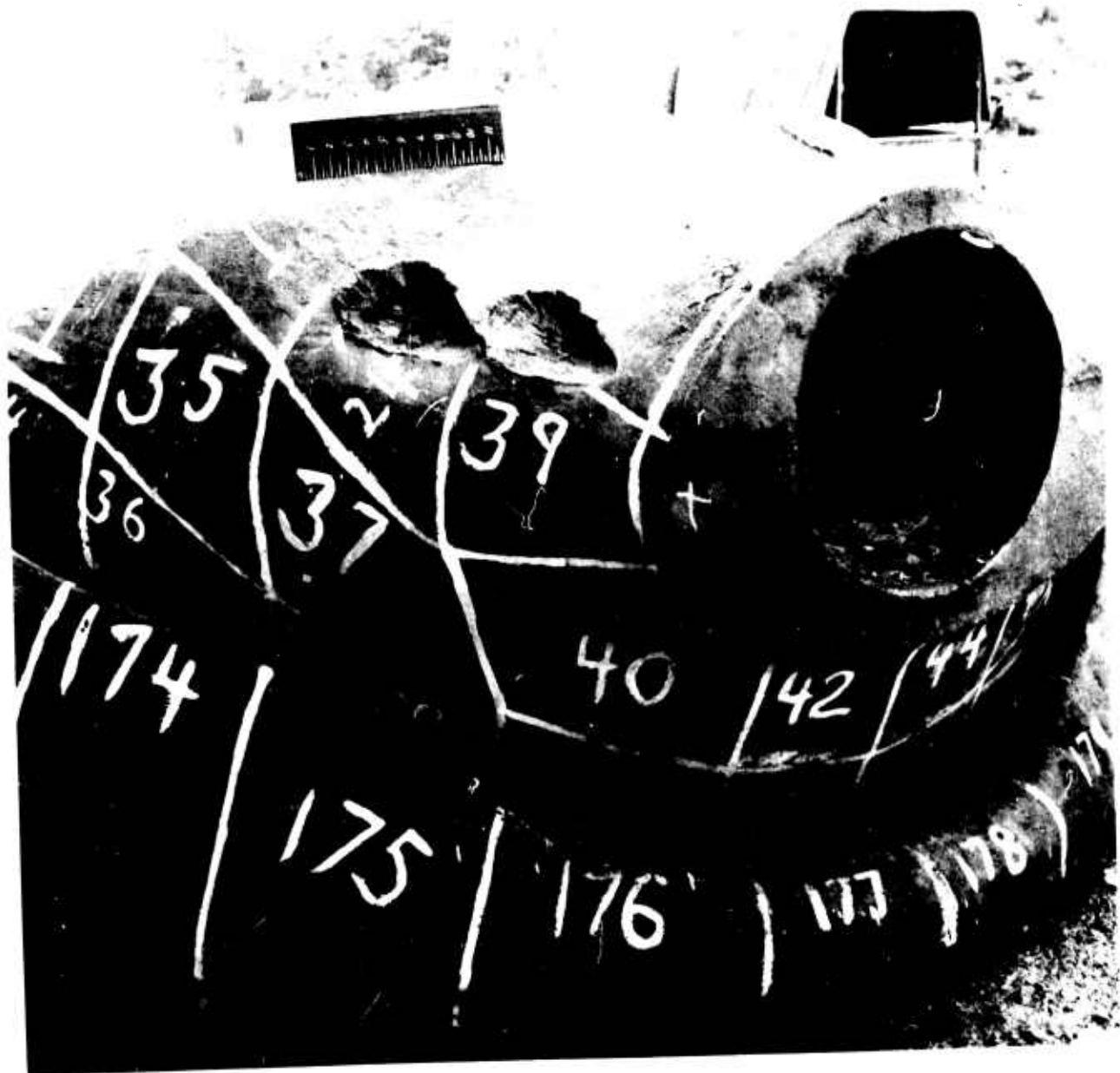


B18541: Inside view of the left side of the turret (rear) showing damage of nine 76mm AP T128E6 projectiles. Three 76mm AP projectiles were fired at 0° obliquity and six were fired at a 60° obliquity. A tenth round was disregarded and is covered by the scale.

D-7

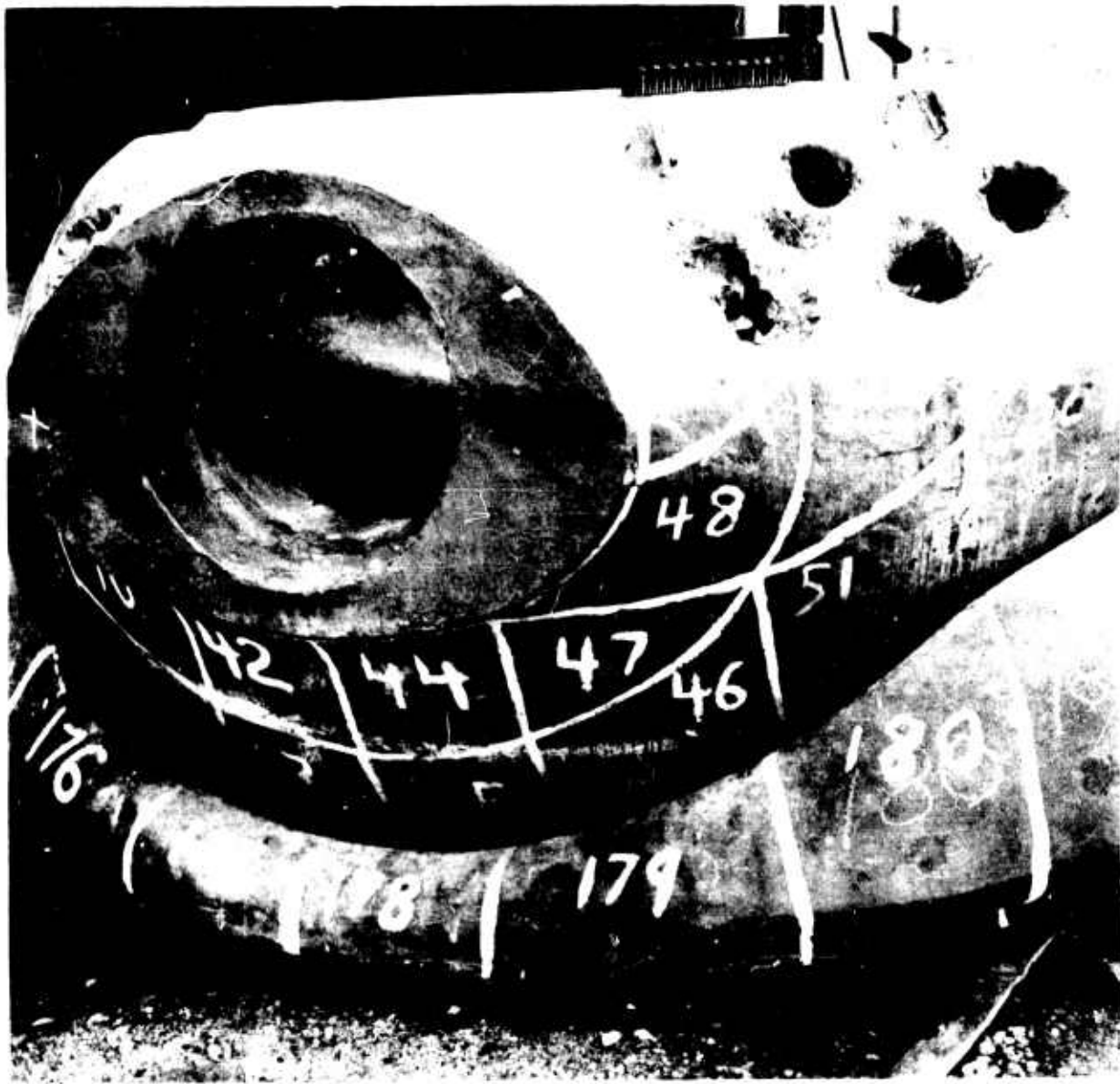
CONFIDENTIAL

CONFIDENTIAL



B18542: Effect of two 90mm AP, T33 projectile impacts from direct front against the right side of the turret. Exterior view.

CONFIDENTIAL



B18543: Effect of eight 90mm AP T33 projectile impacts from a 30° flank against the left side of the turret. Exterior view.

CONFIDENTIAL

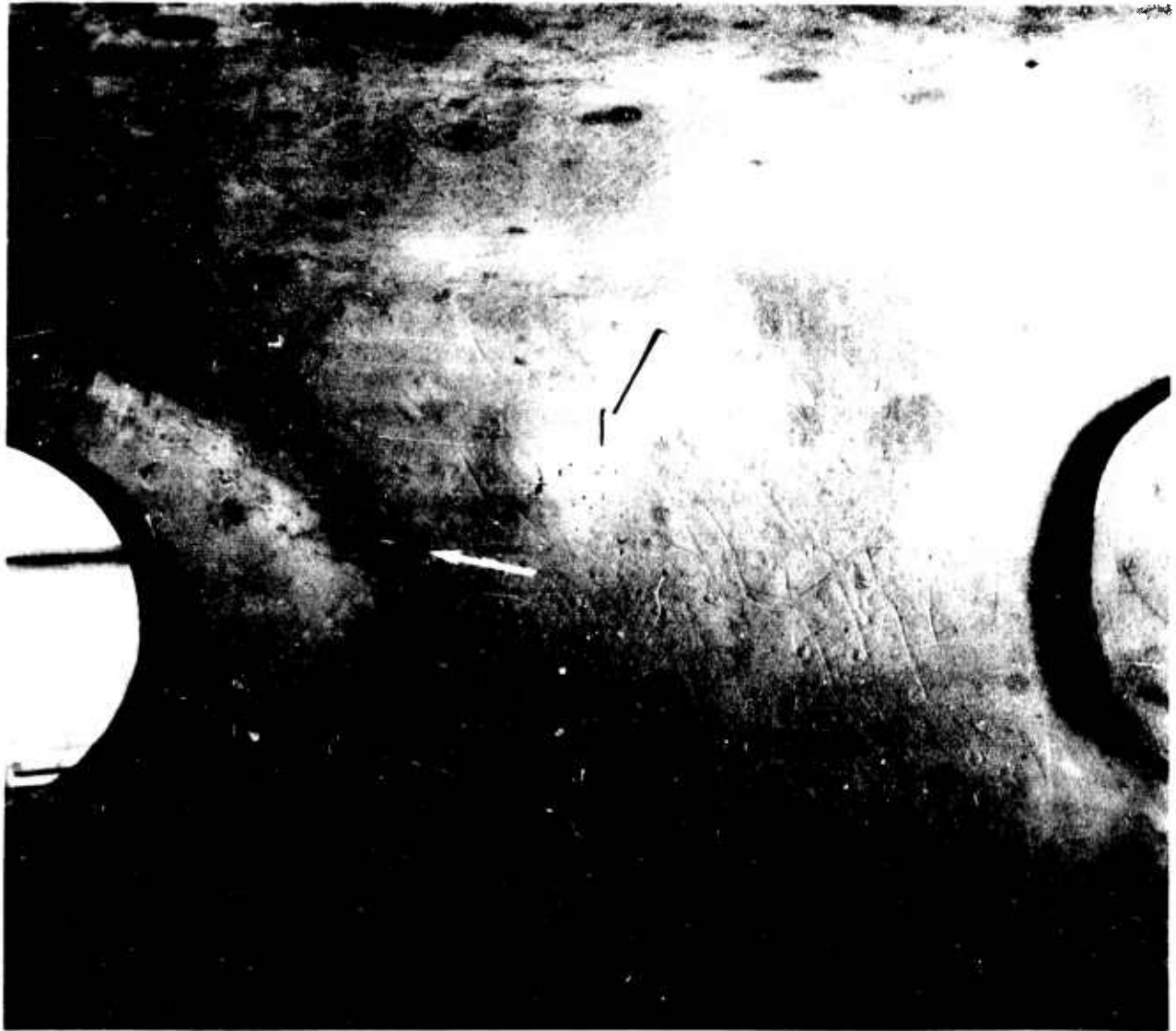


B18544: Effect of eight 90mm AP T33 projectile impacts from a 30° flank against the left side of the turret. Interior view.

D-10

CONFIDENTIAL

CONFIDENTIAL

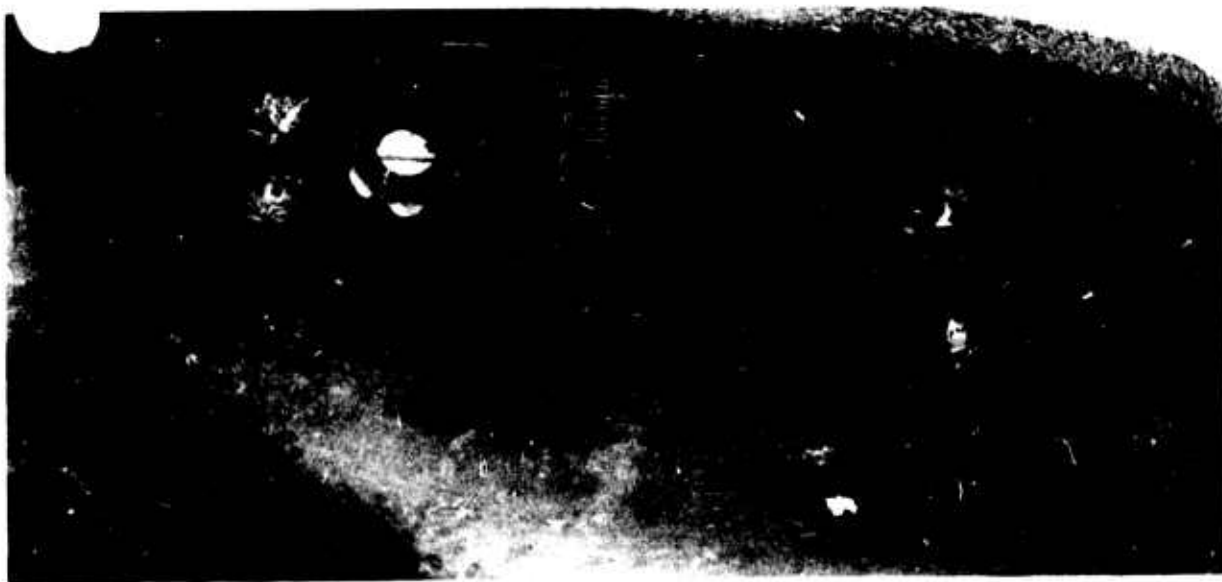


B18545: Effect of two 90mm AP T33 projectile impacts from direct front against the right side of the turret. Interior view. Arrows point to the locations of two cracks.

D-11

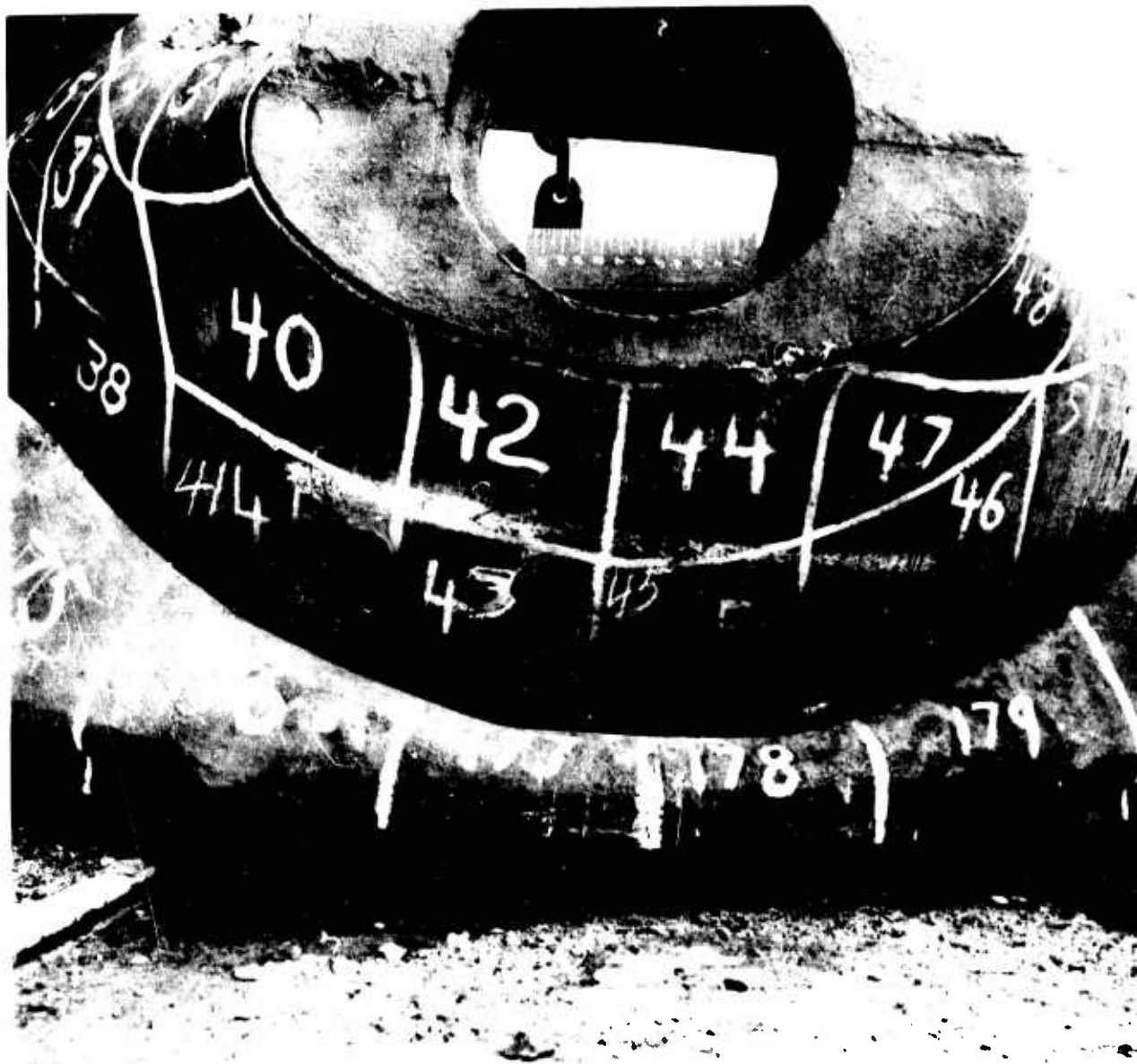
CONFIDENTIAL

CONFIDENTIAL



B18546: Inside view of the right side of the turret (rear) showing damage of eight 76mm AP T128E6 projectiles. Three 76mm AP projectiles were fired at 0° obliquity and five were fired at a 60° obliquity.

CONFIDENTIAL



B18547: Effect of four 90mm AP T33 projectile impacts from direct front below the gun shield of the turret. Exterior view.

D-13
CONFIDENTIAL

Army--Aberdeen Proving Ground, Md--O